The Role Of Titanium Dioxide in the Performance Of Titanium Nitride AMTEC Electrodes

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Components of the Alkali Metal Thermal to Electric Converter (AMTEC) have been studied at JPL for several years with a view to characterizing the performance parameters of the electrochemical cell as a step to understanding the performance of an AMTEC device. One of the components that has been extensively studied is the electrode. Electrode studies typically focus on the sheet resistance in the electrode, the exchange current as measured by the interfacial impedance, and the resistance to sodium flow through the electrode and away from the interface. These parameters are typically reported as R_{sh}, the sheet resistance measured before and after an experiment, B, the temperature independent exchange current, and G, the (dimensionless) morphology factor, respectively [1,2]. In experiments at JPL, these parameters are typically measured in Sodium Exposure Test Cells (SETC) [3] as well as in power-producing AMTEC cells.

If a sodium ion conductor is present in the cathode, it may participate in the reaction of sodium ions with electrons to form sodium atoms by facilitating sodium transfer through the electrode, allowing the recombination of electrons and sodium ions to take place throughout the electrode, thus minimizing resistive losses in the electrode. This effect has been previously noted with the sodium ion conductors sodium molybdate and sodium tungstate early in life for molybdenum and tungsten alloy electrodes, respectively [4]. The performance effect of the presence of an ionic conductor in the electrode would be to increase the magnitude of the exchange current and to decrease the resistance to sodium transfer through the electrode; *i.e.* increasing B and decreasing G.

Pre- and post test analyses of titanium nitride electrodes have shown that in some TiN preparations, there is a significant quantity of titanium-oxygen compounds present. TiO_2 has been identified in the electrode through X-Ray Diffraction. In an AMTEC or SETC experiment, the electrode is exposed to low pressure sodium vapor (~ 10 Pa) at 800 - 950 °C, and any TiO_2 in the electrode may react with Na to become a sodium-titanium-oxygen compound. $Na_{0.5}TiO_2$ has been identified by X-Ray Diffraction in TiN electrodes which were operated from 500 - 2000 hours in low pressure sodium vapor at 850 - 950 °C. To test whether this compound could be formed from TiO_2, TiO_2 powder was heated for 100 hours in low pressure sodium vapor at 850 °C. The product of that reaction was $Na_{0.5}TiO_2$, as measured by gravimetric analysis.

This paper will report the time evolution of the ionic conductivity (sodium) of a TiO_2 film as it is exposed to low pressure sodium vapor in an SETC, and correlate the ionic conductivity to the performance of TiN electrodes which contain TiO_2.

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